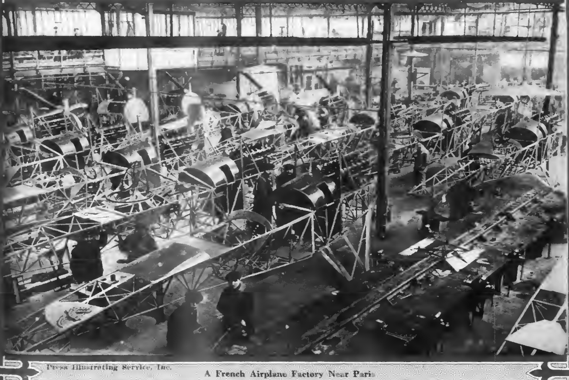
AVIATION

AND

AERONAUTICAL ENGINEERING



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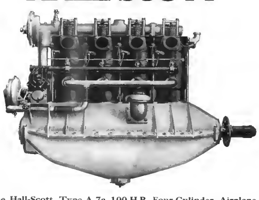

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APRIL 15, 1917 **AVIATION** AND AERONAUTICAL ENGINEERING VOL. II. NO. 6

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AVIATION
AND
AERONAUTICAL ENGINEERING

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Vol. II April 15, 1917 No. 6

IT is a gravely critical fact that the Navy Department can only place on file at present applications for training from civilian fliers who cannot fly and the War Department is in a similar predicament. Civilian schools are assisting in the training of young men who are desirous of entering the services, but the facilities of these schools are entirely inadequate for the training of the 4000 aviators which the National Advisory Committee for Aeronautics has estimated are necessary for our Army and Navy.

The War Department already has more applicants on its lists than there is any possibility of its being able to train for months. Literally thousands of applications for examination for commissions in the Officers Reserve Corps are pigeon-holed in the War Department files. Until the output of machines is enormously increased these applications cannot be acted upon. It has recently been publicly announced that all the airplanes and seaplanes which the Army and Navy together can expect to receive before January 1, 1918, are limited to about 600.

Another limitation upon the Government's ability to train fliers lies in its inability to get a large corps of competent instructors. About five pupils per instructor has been found by experience to give the best results. But the Government's corps of flying instructors is unfortunately small. It has been found that more than one-half the civilian fliers who have sought positions as civilian instructors for the Government were unable to give military instruction in aviation.

The rush of young men anxious to learn to fly has not been equalled by any rush of mechanics anxious to care for airplanes. Civilians anxious to learn to fly are easy to find in thousand lots. Mechanics trained in the care of aeronautical equipment are lamentably scarce. Both the Army and Navy in the regular establishment as well as in the Reserves are anxious to secure first class machinists, carpenters and engine men. The mechanics of an air squadron are almost as responsible for the squadron's success or failure as the aviators. With literally thousands of applications on file from civilians who wish the Government to teach them to fly, there is a noticeable shortage of mechanics of the best type in the Army, the Navy, the Naval Reserve and the Signal Enlisted Reserve Corps.

But even more important and discouraging than the shortage of flying instructors and of mechanics is the limited output of machines. The output of airplanes must be speeded up. In the first place, standardization of parts must be given immediate consideration. It has been on the tip of the tongue wherever aeronautics was discussed for the past year. To date, however, practically no tables of standard parts are available and even where tables are available engineers and draughtsmen are reluctant to utilize standard equipment.

The second thing that can be done to speed up production is the placing of a cash deposit of 25 per cent of the purchase price with every order which the Government places for aeronautic material. At the present time this is specifically forbidden by the laws of the United States. However, it is a practice employed in all daily business by every Government which is at war except the United States. It is of pressing importance that the practice be instituted in this country especially for increasing the output of aeronautic material. Only Congressional legislation will make this possible.

AVIATION AND AERONAUTICAL ENGINEERING does not pretend that the adoption of standards by the constructors or the adoption by the Government of the practice of making part payments in advance will result in getting a sufficient supply of airplanes for the United States. But if the two steps outlined are taken it will be a definite help.

Meanwhile mechanics desiring information about entering the Regular Service or the Signal Enlisted Reserve Corps for aviation duty should apply to the Chief Signal Officer, United States Army, Washington, D. C. If they wish aviation duty with the Navy either in the regular or reserve forces they should apply to the commandant of the Naval District in which they reside.

U. S. A. Aerofoils

In this issue, our readers will find a report from the Massachusetts Institute of Technology on the recent tests conducted there on a number of wing sections developed by the Aviation Section of the Signal Corps, U. S. A. The announcement of these sections marks a distinct advance in aeronautical practice. In using the Eiffel and R. A. F. sections which have been almost universally employed hitherto, constructors have had to pay the penalty for efficiency and good lifting power by more or less successfully combatting structural difficulties.

The development of these sections will go a long way to remove the incompatibility hitherto present between aerodynamical excellence and practical facility of construction. It is too early to say whether some of these sections are altogether superior to such well known wing-curves as those developed by Eiffel and the R. A. F., but further comparative tests are in progress and the indication is that the new wing sections will mark a decided improvement.

Six United States Army Wing Sections

By Captains Edgar S. Gorrell and H. S. Martin, U. S. A.*

These wing sections, developed by the Aviation Section of the Signal Corps, offer considerable interest both from an aerodynamical and a structural point of view. Developed partly from the latter point, they have proved to be efficient and show very satisfactory lift coefficients.

Structural Development of the Sections

In Fig. 1 are shown the dimensioned outlines of the six sections tested. Some of the considerations involved in developing the sections are interesting.

The U. S. A. 1 is a modification of the Clark aerofoil (characteristics and dimensions of which are described in Hunsaker's "*Dynamical Stability of Aeroplanes*"). This was an excellent high speed wing with a maximum lift drift of 18. By increasing the depth at the position of rear spar, it was made structurally much more practical, the maximum lift was increased and the maximum lift drift ratio only reduced very slightly.

The U. S. A. 2 has the same upper surface as the R. A. F. 3 but the lower surface has been modified and deepened from a structural point of view, without any loss from the aerodynamical point of view.

The U. S. A. 3 and U. S. A. 4 are both modifications of the U. S. A. 2. In the first section, the nose of a 30 in. chord has been moved forward ¾-in. and the ordinates of the first fifth of the 30-in. chord spread out accordingly. In the U. S. A. 4, the nose of a 30-in. chord has been moved back ¾-in. and the ordinates of the first fifth of the 30-in. chord crowded out accordingly.

The U. S. A. 5 was skillfully developed from both structural and aerodynamic considerations, with very satisfactory results.

Results of Tests

The tests were conducted under the standard conditions. Results for Ky, Kx, L/D and center of pressure motion are given in Table 1, and in the curves of Figs. 2, 3 and 4. The wind tunnel speed was 30 m. p. h. in every case, and the models 18 in. span by 3-in. chord—the dimensions generally employed, and useful on that score for purposes of comparison.

The National Physical Laboratory results, as published in the British Reports, are based on LV (chord of wing in feet × velocity of relative wind in feet per second) values of 6.3. In Eiffel's large laboratory with greater wind speeds the values of LV range from 16 to 40. The Institute tests are conducted with an intermediate value of 11 for LV. It is, therefore, not possible to make strictly accurate comparisons with the Eiffel tests which are now in progress at the Institute. It is, however, perfectly clear that, apart from the good structural features, the sections have remarkably good aerodynamic properties.

In Table 2, comparative figures for the six sections are set out in accordance with the plan employed in the Course in Aerodynamics and Airplane Design (Aviation and Aeronautical Engineering, October 1, 1916), together with values for the R. A. F. 3, R. A. F. 6, and Eiffel 32; the drift and L/D values for the latter being subject to revision as stated on completion of above tests.

For none of the wings does the maximum Ky fall below .003, except almost negligibly so for U. S. A. 6. For all the wings, there is a wide range of working angles. None of them exhibit a sharp drop at the burble point. With the exception of U. S. A. 4, they all have good maximum values of L/D at the small ... Ky = .00086. From the center of pressure curves of Fig. 4 it is seen that none of the wings may be said to be longitudinally stable but none of them have a violent center of pressure motion within the usual range.

TABLE 2

Aerofoil	LV (velocity of wing in ft. × chord in feet)	Angle in degrees	Maximum L/D: K_y	L/D	Angle in degrees	Maximum K_y: K_y	L/D	L/D, K_y = .00086: Angle in degrees	L/D
U S A 1	11	3.0	.00135	17.8	14.0	.00318	9.8	[illegible]	11.8
U S A 2	11	4.0	.00160	16.1	14.0	.00357	9.3	[illegible]	9.6
U S A 3	11	4.0	.00170	16.4	14.0	.00324	9.6	[illegible]	10.4
U S A 4	11	3.0	.00177	14.88	15.0	.00364	9.1	[illegible]	9.1
U S A 5	11	3.0	.00136	16.1	14.0	.00328	9.2	[illegible]	11.6
U S A 6	11	3.0	.00148	17.4	14.0	.00298	7.57	[illegible]	10.3

Foreign Sections

Aerofoil	LV (velocity of wing in ft. × chord in feet)	Angle in degrees	Maximum L/D: K_y	L/D	Angle in degrees	Maximum L/D: K_y	L/D	K_y = .00086: Angle in degrees	L/D
Eiffel 32	49		0.00280		10	0.00103	18.2	[illegible]	18.0
R A F 3	6.4	17.7	0.00347	7.8	8	0.00105	14.1	[illegible]	17.4
R A F 6	6.3	15.4	0.00310	8	4.9	0.00187	11.0	[illegible]	10.4

with modern non-lifting tail surfaces, no difficulty would be met in securing longitudinal stability.

It is noteworthy that the U. S. A. 4 has a higher maximum lift coefficient than almost any wing section tested, —.00364, compared with .00347 of the R. A. F. 3. It should have an L/D of approximately the same value and as far better structurally. This wing would seem to be particularly suitable for very heavy machines such as seaplanes.

U. S. A. 1 has a higher lift than Eiffel 32—namely, .00318 compared with approximately .00280—and its maximum L/D of 17.8 would in the Eiffel tunnel probably exceed the 18.2 of the French wing. Although for small values of Ky and high speeds, the Eiffel 32 has better efficiency, U. S. A. 6 also with a higher maximum lift, would compare most favorably in a high speed machine with any French wing at which data has hitherto been published. For pursuit machines the choice between U. S. A. 1 and 6 would be very close. U. S. A. 1 would give a better landing speed and U. S. A. 6 is slightly more efficient at low angles and high speeds.

U. S. A. 2 and 3 would be good all round wings apparently slightly better than the R. A. F. 6.

An interesting feature of the series is the successful employment of heavy camber on upper and lower surfaces. It has been commonly accepted that heavy camber meant increase in lift with corresponding decrease in efficiency, while lightly cambered wings would give high efficiency but low lift. With skillful design, it is apparently possible to retain both good features.

* By permission of Professor C. H. Peabody, Professor of Naval Architecture in Charge of Department of Aeronautical Engineering, Massachusetts Institute of Technology. Assisted by Alexander Klemin and T. H. Huff.

AERODYNAMIC LABORATORY TESTS

TABLE 1

U. S. A. 1

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge, in fractional part of chord
—4°	— 000399	0001315	2 04	
—2°	000188	0000905	1 72	
—1°	000432	0000700	6 1	620
0°	000721	0000653	11 00	530
1°	000936	0000670	14 00	463
2°	001146	0000688	16 60	415
4°	001510	0000860	17 50	340
6°	001878	0001158	16 20	318
8°	002230	0001558	14 30	303
10°	002580	0002035	12 80	290
12°	002910	0002795	11 20	283
14°	003165	0004040	10 40	274
16°	003165	0003780	8 50	276
18°	004080	0006420	6 60	310
20°	002882	0008400	4 40	360

U. S. A. 2

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge, in fractional part of chord.
—4°	— 0001331	0001640	—0 73	
—2°	0005200	0001130	4 52	670
—1°	0007650	0001075	7 11	525
0°	0009700	0001032	9 44	461
1°	0011840	0001007	11 80	416
2°	0013820	0000993	13 90	398
4°	0017700	0001115	16 88	347
6°	0019800	0001340	14 80	330
8°	0025400	0001900	13 30	293
10°	0029900	0002335	11 70	273
12°	0034100	0003100	10 67	276
14°	0036000	0003515	10 15	276
16°	0036130	0004410	8 15	276
18°	0034700	0005580	6 22	303
20°	0031000	0007640	4 06	335

U. S. A. 3

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge in fractional part of chord.
—4°	— 000728	0001147	—1 8	
—2°	000303	0001098	3 1	733
—1°	000625	0000941	6 64	522
0°	000862	0000872	9 88	445
1°	001075	0000846	13 26	388
2°	001292	0000848	15 2	352
4°	001678	0001027	16 14	317
6°	002080	0001330	15 80	292
8°	002432	0001771	13 88	276
12°	003179	0002701	11 7	255
16°	003362	0004401	8 31	247
18°	003100	0005401	7 11	223
20°	002770	0008 1	3 18	230

U. S. A. 4

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge, in fractional part of chord.
—4°	— 000326	0001 .00	—1 58	
—2°	000346	0000948	3 64	733
—1°	000636	0000840	7 67	566
0°	000910	0000741	12 28	498
1°	001145	0000803	14 28	444
2°	001353	0000863	15 72	415
3°	001565	0000966	16 21	377
4°	001740	0001092	15 96	348
5°	001930	0001290	15 35	337
8°	002470	0001830	13 52	315
10°	002870	0002380	12 06	303
12°	003130	0002890	10 84	300
13°	003240	0003290	9 34	298
14°	003265	0003545	9 23	288
15°	003235	0003910	8 28	292
16°	003205	0004210	7 63	298
18°	003130	0006003	4 57	330
20°	002790	0008200	3 41	368

U. S. A. 5

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge in fractional part of chord
—4°	— 000306	0001 .80	1 10	
—2°	000420	0001100	1 99	678
—1°	000692	0000811	8 31	482
0°	000928	0000831	11 10	403
1°	001123	0000870	11 11	333
2°	001110	0000881	14 7	323
3°	001508	0000934	16 16	294
4°	001704	0001071	15 88	280
5°	001919	0001180	16 18	260
8°	002520	0001821	13 81	230
10°	002905	0002290	12 70	220
12°	003160	0002830	11 1	208
13°	003231	0003142	10 30	204
14°	003240	0003410	9 6	197
15°	003218	0003780	8 51	167
16°	003155	0004491	7 11	197
18°	003125	0006620	4 71	236
20°	002980	0008670	1 1	298

U. S. A. 6

L of i	K_y	K_x	L/D	Distance of C. P. from leading edge in fractional part of chord
—4°	— 000276	0001905	—1 98	
—2°	000272	0000793	3 41	810
—1°	000567	0000671	6 46	600
0°	000845	0000650	13 00	496
1°	001037	0000668	15 88	458
2°	001255	0000733	17 15	439
3°	001455	0000858	16 95	402
4°	001682	0000976	17 05	388
5°	001846	0001131	16 48	365
8°	002415	0001665	14 50	322
10°	002650	0002180	12 27	308
12°	002884	0002820	10 15	310
13°	002910	0003200	6 94	310
14°	002980	0004030	7 37	310
15°	002980	0005300	5 58	328
16°	002900	0006380	4 55	346
18°	002780	0007900	3 53	365
20°	002385	0009000	2 68	358

L of i = Angle of wing chord to wind.
K_y = Lift coefficient in lbs./sq. ft. MPH.
K_x = Drift coefficient in lbs./sq. ft. MPH.

L/D = Ratio of lift to drift.
Model Size 18" × 3" (54 sq. in.). Material Brass.
Velocity of wind 30 MPH.
Density of standard air .07608 lbs. cu. ft.

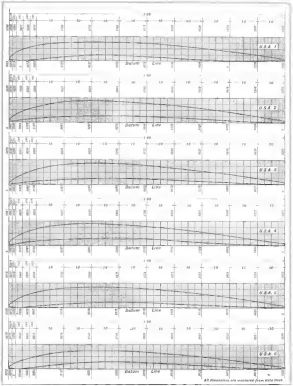

U.S.A. 1
Datum Line
U.S.A. 2
U.S.A. 3
U.S.A. 4
U.S.A. 5
U.S.A. 6
All dimensions are measured from data lines.

FIG 1

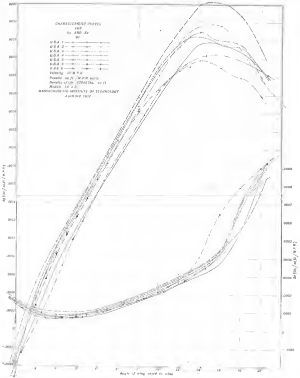
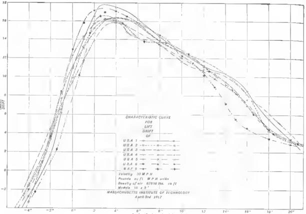

CHARACTERISTIC CURVES
FOR
Ky AND Kx
OF
U.S.A 1
U.S.A 2
U.S.A 3
U.S.A 4
U.S.A 5
U.S.A 6
R.A.F 6
Velocity 30 M.P.H
Pounds sq ft / M.P.H units
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
April 3rd 1917
Angle of wing chord to wind

FIG 2

FIG 3



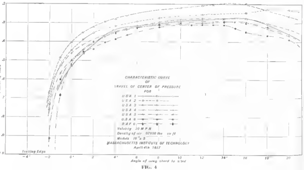


FIG. 4

Course in Aerodynamics and Airplane Design*

By Alexander Klemin, A.C.G.I., B.Sc., S.M.

Instructor in Aeronautics, Massachusetts Institute of Technology, Member of the Aeronautical Society of Great Britain and Ireland,

and

T. H. Huff, S.B.

Instructor in Aeronautics, Massachusetts Institute of Technology

PART II—SECTION

Materials in Airplane Construction

Within the limits of one section it is impossible to treat adequately all the data on materials required for airplane construction. The data included here will be sufficient for the purpose of our design, however, and a number of references are appended. For practical work, the designer must procure all necessary handbooks, make tests of his own special fittings, and generally collect his own data.

The Special Utility of Wood in Airplane Construction

It is the remarkable strength for its weight which makes wood so useful in airplane construction. If we compare spruce, weight per cubic foot 26 lb., tensile strength 9000 lb., with mild steel weighing 490 lb. per cubic foot with a tensile strength of 60,000 lb., the spruce will be $\frac{9000}{60,000} \times \frac{490}{26} = 2.9$ times as strong for the same weight.

The selection, mechanical properties and correct structural employment of timber are, however, inexhaustible subjects and the following notes are the briefest summary of the factors the designer must have in mind.

Weight of Wood

The weight of wood varies greatly for the same species and for portions of the same tree. Sapwood is heavier than heart wood, summerwood than springwood. Green timber naturally weighs more than dry timber, due to the presence of sap and moisture. The ultimate wood fiber of all species has a specific gravity of 1.6, so that no wood would float in water were it not for the buoyancy of the air present in the cells and walls.

The weight of wood is experimentally determined by subjecting thin discs to an oven temperature of 100° Cent. until they cease to lose weight by evaporation of moisture. But even with this provision, the results will be extremely variable, and the value usually assigned to a given species is simply the average of a large number of tests. Table 1, taken from a Bulletin of the Forestry Division, United States Department of Agriculture, will give values sufficiently accurate for design.

Weight is a good indication of the strength of wood, provided the amount of moisture contained is known. As a general rule, we may say that a comparison of two woods, each containing the same percentage of moisture, will show the heavier to be the stronger; in fact, the strength will be very nearly proportional to the weight.

TABLE 1

Specific Gravity and Weights of Woods

Dry woods	Wt. per cu. ft., lb.	Specific gravity
Ash, American white	38	618
Balsa	[illegible]	104
Boxwood	60	960
Cherry	42	672
Chestnut	41	660
Cork	15	230
Elm	35	560
Ebony	76.1	1.220
Hemlock	25	400
Hickory	53	850
Lignum-vitae	83	1.330
Mahogany, Spanish	53	850
Mahogany, Honduras	35	560
Maple	49	790
Oak, live	59.3	950
Oak, white	48	770
Oak, red	40	640
Pine, white	25	400
Pine, yellow	[illegible]	530
Pine, southern	[illegible]	720
Sycamore	[illegible]	590
Spruce	[illegible]	400
Walnut	38	610

Factors in the Mechanical Properties of Woods

The strength properties of wood depend on (1) correct identification of species and variety, (2) age and rate of growth, (3) position of test specimens in the tree, (4) moisture content, (5) relative freedom from defects, such as knots, etc.

Tensile Strength

Tensile tests are difficult because tests cannot be devised that do not involve either shear along the grain or compression across the grain. It is for the same reasons that wood may be unsuitable in tension though it is apparently strong under such a stress.

Failure in tension along the grain involves principally the resistance offered by the wood elements to being torn apart transversely or obliquely. The strands of wood elements are practically never pulled apart by failure of the union between adjacent strands or fibers.

Cross grain is prejudicial to tensile strength and rays, owing to their transverse position with respect to a load applied along the grain, and small resistance to tension in a direction normal to the direction of their fibers greatly weaken the timber. Knots weaken wood subjected to longitudinal tension.

Compressive Strength

Individual fibers act as so many hollow columns bound firmly together, and failure involves either buckling or bending of the individual fibers or bundles of elements which finally come to act almost independently.

Compressive strength depends on a number of factors: (1) density, (2) strength of union between individual fibers as affected by moisture content, (3) stiffness of wood fibers (again largely a matter of moisture content), (4) continuity of the course of longitudinal strands in a direction parallel to axis of the piece. Woods in which separate elements are closely interlaced and bound together will be stronger than woods of opposite character.

The strongest woods in compression with the grain are, roughly, in the following classes:

(1) The dense and tough hickory, birch, hard maple, etc., (2) oak, elm, ash. (3) spruce, pine and fir.

Crushing Across the Grain

Crushing strength across the grain is dependent practically entirely upon the density of the wood. Crushing strength across the grain is, therefore, least for the lightest, most porous woods, and greatest for heaviest and densest woods.

Compressive strength across the grain is to compressive strength along the grain as 13 to 14 per cent for white pine, cedar, cypress and spruce, 15 to 16 per cent for the various grades of hard pine, 18 to 26 per cent for elms, 21 to 26 per cent for ash, 22 to 26 per cent for oaks, 23 to 31 per cent for hickories.

Strength in Bending

In considering the strength of a wooden beam in bending, several difficulties occur. Longitudinal shear is very important. A wing spar may be amply strong in bending, and yet if

* This Course commenced in the August 1, 1916, issue of AVIATION AND AERONAUTICAL ENGINEERING will be completed in 24 issues.

highly channeled out fail by longitudinal shear The tensile fiber strength of wood is much in excess of the compressive stress, but even if the compressive fiber stress of wood is employed in the formula $f = \frac{M_c}{I}$, it is no true criterion. If this formula is employed for strength computations in bending, it is assumed that the material is still behaving elastically up to actual failure, and therefore that the fiber stress is still directly proportional to the distance of the fiber from the neutral axis As a matter of fact, the elastic limit of the material may have long been passed when the breaking load is reached, the neutral axis may have shifted, and the extreme fiber may be no longer proportional to the bending Therefore, in stress calculations for wing spars, these considerations should be applied, making use of the modulus of rupture—for which values are given in Table 2—deduced from actual bending tests, which are far more trustworthy guides

Knots

Knots originate in the timber cut from the stem or branches of a tree because of the envelopment of a limb, either living or dead, by the successive annual layers of wood Most limbs originate at the pith of the stem, and the knots found deep in a log are therefore small, increasing in size toward the bark So long as the limb is growing, its layers of wood are a continuation of those of the stem But a majority of the limbs die after a time, and if a portion of a dead limb is subsequently encased by the growing stem, there will be no intimate connection between the new stem wood and the dead wood of the limb, and a board so cut as to intercept this portion of the log will contain a loose knot. A board cut from the log at such a depth that the limb is intercepted at a point where it was encased while still living will contain a sound knot, unless the knot has rotted, becoming badly checked, or contains a large pith cavity.

A sound knot is usually harder than the surrounding wood, and in coniferous woods is apt to be very resinous On this account it may constitute a defect because of its non-retentivity of paint or varnish Otherwise it constitutes a defect only on account of the disturbance to the grain and difficulty caused in working, or in the event of its occurrence on the under side of a timber used as a beam, a weak point exists, owing to its small resistance to tensile stress. A knot constitutes an impediment to the splitting of timber, since the fibers of the stem wood above a limb bend aside and pass around the limb, while the fibers below run continuously into the limb Thus it often happens that a cleft started above a limb will never run into a knot, but one started below is very apt to do so

The Effect of Moisture on Strength of Wood

Loss of moisture does not affect the strength of wood in any way, until the total moisture content has been reduced below the critical percentage, which represents the fiber-saturation period Beyond this point, progressive loss of moisture affects the strength very considerably. Thus the strength of green wood is only 50 to 60 per cent of normal air-dry conditions (12 per cent moisture), while the strength of kiln-dry wood exceeds the strength of air-dry woods by some 50 to 70 per cent

Time Factor in Tests of Timber

Timber differs from most other materials in that small variations in the rate of application of load have a more pronounced effect upon the strength and stiffness shown by a specimen under test. If a timber compression block or beam is loaded rapidly, it will appear to have a higher elastic limit and ultimate strength, and will also appear to be stiffer, than it will if loaded less rapidly. This is due to the fact that the deformation lags far behind the load, and if any load is permitted to remain upon a specimen for a time the deformation increases, the amount of increase becoming greater for heavier loads Actual failure appears to be consequent upon the attainment of a certain limiting amount of deformation or strain, rather than a limiting load or stress.

Difficulties of Wood Construction in Airplanes

The comparative values of Table 2 demand the most careful study. A certain type of timber may be most suitable for the direct stress to which it is subjected, yet fail completely under certain indirect stresses, either inherent in the construction or due to faulty design For example, at the hinging of a wing spar to the body, if the bolts are not correctly placed, they may shear out the wood. These points will be considered in detail in the design, but enough has been said to show the value of studying not only the direct stresses on a piece of timber in a machine, but also the indirect stresses producing crushing across the grain, shear, etc

Strength Values for Timber

In no material are such conflicting values given by various authorities as for timber The size of the specimen under test, the dryness, the method of applying the load, and its previous history, all tend to introduce discrepancies Until the Bureau of Standards, or some other testing laboratory, has gone thoroughly into the question, all the values employed by airplane constructors will be open to suspicion Table 2 is a summary of information taken from various sources. This table is not unimpeachable, but it approximates closely values used in current practice In airplane design, fiber stress is still taken as a criterion, without the consideration of the modulus of rupture

TABLE 2

Material	Tensile strength with grain	Tensile strength across grain	Compressive strength with grain	Compressive strength perpendicular to grain (fiber stress at elastic limit only)	Shearing strength parallel to grain	Hardness load required to imbed a 0.444 in. ball in half its diameter	Modulus of rupture in static bending	Modulus of elasticity
Ash	12,000	1,600	9,000	1,000	1,400	[illegible]	15,000	1,600,000
Balsa	11,000	1,000	1,200			[illegible]		
Beech	11,000	1,400	8,000		1,300		10,000	1,330,000
Birch	15,000	1,800	1,400		1,050		11,400	1,400,000
Cedar	10,800	[illegible]	[illegible]				[illegible]	600,000
Elm	10,500		7,000				8,800	1,000,000
Hickory	15,000	[illegible]	11,000	[illegible]	1,400		[illegible]	1,800,000
Mahogany	10,000		8,200				11,000	1,240,000
Maple	17,500	1,400	7,100	900	1,150		[illegible]	1,000,000
Oak	15,000	2,000	7,000		1,250	1,150	10,000	1,300,000
Pine yellow	11,000	1,200	[illegible]	[illegible]	610	110	[illegible]	1,000,000
Pine white	10,000	1,100	[illegible]	[illegible]	640	301	[illegible]	1,100,000
Spruce	11,000	600	[illegible]	100	600	27.2	[illegible]	1,300,000

Acknowledgement is due Prof W H. Keith for collaboration on brief notes on timber.

Wires and Cables

The following terms are in common use: (1) "Solid wire stay" or "aviation wire" of one wire of suitable diameter (2) "strand stay," consisting of either 7 or 14 wires stranded together and known to the trade as "aviation strand", (3) "cord" or "rope stay," consisting of 7 strands twisted together, forming a rope, the strands being either 7 wires or 19 wires, (4) "flexible cord," composed of six strands of seven wires, with a center of either cotton or wire, as ordered The cord with the cotton center is considerably more pliable than that with the wire center

Vanadium steels and other special steels have not as yet become established as desirable wire steels, and carefully made high grade carbon steel is at present most largely employed in the manufacture of wires and cables

Properties of Metals

Only the briefest outline can be given of the metals that are commonly employed in airplane construction. To enter into any adequate discussion of this branch of the work would require a book in itself The constructor must keep constantly before him some standard book on this subject and at the same time resort to strength of material and part tests whenever new combinations are to be employed in his design

The following table of weight and melting points for various metals may be of service:

Metal	Weight per cu in	Weight per cu ft.	Specific Gravity	Melting point Fahr
Aluminium	.096	166	2.56	1,215
Antimony	.242	418	6.70	786
Bismuth	.350	607	9.74	518
Brass, cast	.292	504	8.10	1,635
Brass, rolled	.303	524	8.40	
Bronze, gun metal	.305	529	8.50	1,600
Copper, cast	.314	542	8.70	1,980
Copper, rolled	.321	555	8.90	
Duralumin	.103	178	2.85	(approx.) 1,200
Gold, 24 carat	.694	1,204	19.26	1,950
Iron, cast	.260	450	7.21	2,012
Iron, wrought	.278	480	7.70	2,912
Lead, cast	.410	710	11.38	621
Mercury 60 Fahr	.489	846	13.58	
Monel metal	.320	553	8.85	2,480
Platinum	.776	1,342	21.50	3,226
Silver	.378	655	10.50	1,762
Steel, rolled	.283	490	7.85	2,552
Tin, cast	.266	459	7.35	450
Zinc, cast	.248	428	6.88	786

TABLE 3

Strength and Weights for Wire and Cables

SOLID WIRE

Raebling Solid Wire

Diameter of cord, Inches	Breaking strength of cord, Pounds	Approximate weight per 100 ft. Pounds
1/16	400	.73
5/80	480	.83
3/32	760	1.30
7/64	830	1.50
1/8	1,130	2.20
5/32	2,200	4.20
3/16	2,750	5.70
7/32	4,000	7.41
1/4	5,000	4.50
5/16	7,800	13.00

AVIATOR WIRE STRAND

Roebling's 19 wire galvanized

1/32 (7 wire)	185	0.30
1/16	500	0.78
5/64	780	1.21
3/32	1,100	1.75
7/64	1,600	2.60
1/8	2,000	2.88
5/32	2,800	4.44
3/16	4,200	6.47
7/32	5,600	9.50
1/4	7,000	12.00
9/32	8,000	14.56
5/16	9,800	17.71
11/32	12,500	22.53
3/8	14,400	26.45

American Steel and Wire Co galvanized (19 wire) airplane strand

1/32 (7 wires)	125	.23
1/16	500	.80
3/32	1,100	1.70
1/8	2,000	3.4
5/32	3,000	5.1

AVIATOR CORD

Roebling's 7 by 19 heavily tinned

1/8	2,000	2.88
5/32	2,800	4.44
3/16	4,200	6.47
7/32	5,600	9.50
1/4	7,000	12.00
9/32	8,000	14.56
5/16	9,800	17.71
11/32	12,500	22.53
3/8	14,400	26.45

FLEXIBLE CORD

Roebling extra flexible aviator cord, 6 x 7 cotton center

5/16	9,200	16.70
1/4	5,800	10.50
7/32	4,600	8.30
3/16	3,300	6.30
5/32	2,000	4.67
1/8	1,355	2.35
7/64	970	1.75
3/32	920	1.45
5/64	550	.93
1/16	485	.81

American Steel and Wire Co galvanized or turned flexible cord

3/16 (19 x 7)	2,600	5.52
5/32 (19 x 7)	1,800	3.85
1/8 (16 x 3)	1,150	2.45
3/32 (12 x 3)	725	1.55

Wire, Strand or Cord

Roebling's report does not settle the question as to which is a correct selection. A comparative table shows the progressive decrease in strength

Material.	Diameter	Strength of material.	Strength of stay
Wire	3/16	5,300	5,100
Strand	3/16	4,600	4,100
7 by 19 cord	3/16	4,200	3,800

A stranded or cord stay has about 20 per cent more aerodynamical resistance than a solid wire of about the same diameter There appears to be a slight advantage in favor of solid wire as regards strength of stay. On the other hand, the strand stay is one and a third times more elastic, the cord one and three-quarter times more elastic than the solid wire In American practice all three types of stays appear No doubt the use of strand or cord is justified by the extra elastic stretch and flexibility

Exact data on the fatigue values of the three materials is not available, but it is well known that strand or cord will stand up much better to vibration than a wire. Also in a continuous beam structure such as that of a wing, there may be deflections of unknown magnitude, in which case the more elastic cable will be somewhat safer On the other hand an exposed cable is liable to damage. A single small wire of one strand may be damaged and lead to the eventual destruction of the whole cable In the covered in body a cable is not likely to be damaged. The problem is by no means settled yet, and only comparative experience in actual flight and further experimentation can give a definite solution.

Turnbuckles

The breaking strength of turnbuckles made of precisely the same material will vary enormously with every type of construction, and the makers' catalog or data sheet has to be consulted for every special case In Figs 1 and 2 are shown two representative types, the Curtiss and the National, Burgess, Meyer, Binet types The weights and strength values are fairly representative of what can be obtained from this important brand of airplane material In Table 4 are given results of tests on some specimens of the Standard Screw Co. of Pennsylvania

TABLE 4

Standard Screw Co Turnbuckles

Manufacturer number	Mean breaking load	Mean breaking load from test.	Initial shank area per sq. in	Weight in lb Long barrel male
326	2,150	2,432	.01964	.122
327	2,850	3,426	.0280	.167
328	3,000	4,605	.0350	.238
329	5,000	6,545	.0515	.275
330	[illegible]	8,530	.0794	.411

Mean tensile strength of shank 128,810 lb per sq. in Material—shank, 3½ per cent. nickel steel heat treated barrel cabin bronze Turnbuckles are made in short and long male and female ends

Strength of Steel—Lbs. per Sq. Inch

	Tension Ultimate	Tension yield point.	Compression Ultimate	Compression yield point.	Shearing Ultimate	Shearing yield point.
0.05% C for rivets	45,000	22,000	70,000	40,000	45,000	22,000
0.10% C boiler plate	55,000	30,000	85,000	85,000	50,000	28,000
0.25% C structural.	65,000	34,000	110,000	85,000	55,000	32,000
0.40% C rails	70,000	45,000	120,000	90,000	60,000	35,000
0.90% C machinery	90,000	70,000*	140,000	110,000*	70,000	*45,000
1.00 to 2.00% tool	150,000	none	200,000	none	120,000	none

*When well annealed

	Modulus of elasticity Direct	Shearing	
0.05% C	26,000,000	13,000,000	
0.10% C	26,000,000	13,500,000	
0.25% C	30,000,000	14,000,000	
0.40% C	30,000,000	14,000,000	
0.90% C	31,000,000	14,500,000	When well annealed.
1.00 to 2.00% C	35,000,000	18,000,000	When hardened.

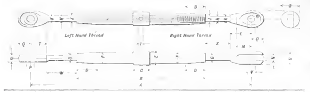
	Modulus of Rupture
For flat plates	1.0 (t. s.)
For squares	1.2 (t. s.)
For high rectangles	1.5 (t. s.)
For rounds and diamonds	1.8 (t. s.)

Strength of Steel Castings—Well Annealed—Lbs. per Square Inch

Small Castings

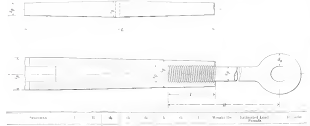
Tension Ultimate	Tension yield point	Compression Ultimate	Compression yield point	Shearing Ultimate	Shearing yield point
60,000	30,000	80,000	45,000	48,000	25,000

Modulus of elasticity (direct) 29,000,000
Modulus of elasticity (shearing) 13,000,000
Modulus of rupture in same ratios as above



Curtiss No.	No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Threads Per Inch	Breaking Strength	Cable	Weight
Special		7⅛	4	½	½	[illegible]	3/16	11/16	3.20	3/16	[illegible]	[illegible]		3/16	[illegible]	11/16	3/16	[illegible]	3/16	11/16	[illegible]	11/16	3/16	[illegible]	[illegible]	24	8846	¼ in. Cable	
3	326	6	4	3/16	3/16	[illegible]	11/16	3/16	1.59	[illegible]	.203	[illegible]	[illegible]	[illegible]	110	3/16	3/16	11/16	[illegible]	[illegible]	[illegible]	3/16	3/16	[illegible]	[illegible]	30	2183		
4	327	7 11/16	4	½	[illegible]	11/16	11/16	3/16	1.87	3/16	.214	3/16	11/16	[illegible]	11/16	3/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	4017	¼ in. Cable	
5	328	7 11/16	4	½	11/16	[illegible]	3/16	[illegible]	2.1[illegible]	3/16	.26[illegible]	3/16	[illegible]	3/16	11/16	[illegible]	[illegible]	11/16	[illegible]	11/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	3993		
6	329	7 11/16	4	½	[illegible]	11/16	11/16	3/16	2.38	3/16	3/16	[illegible]		[illegible]	11/16	3/16	3/16	11/16	3/16	[illegible]	3/16	3/16	3/16	[illegible]	[illegible]	24	5750		
	326-S	3 11/16	2	3/16	3/16	[illegible]	11/16	3/16	1.39	[illegible]	.203	[illegible]	[illegible]		110	3/16	3/16	11/16	3/16	[illegible]	[illegible]	[illegible]	3/16	[illegible]	11/16	30	2183	1/16 Wire	
	327-S	4 3/16	2¼	½	[illegible]	11/16	11/16	3/16	1.87	3/16	.234	3/16	[illegible]	[illegible]	110	11/16	[illegible]	[illegible]	3/16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11/16	48	3037	[illegible] Wire	

Material.—Mang. Bronze and 55-Ton Steel
Fig. 1.—Curtiss Turnbuckles.



Specimen	l	H	d_1	d_2	d_3	l_1	d_4	[illegible]	Weight lbs.	Estimated Load Pounds	Remarks
National No. 324	3.35	1.30	26	21	11	15	20	45	019	1150	Failure in shank
National No. 327	2.50	2.50	40	32	19	23	31	60	161	2200	Yield in barrel
National No. 328	5.00	2.75	48	17	20	27	40	65	229	2800	Yield in barrel
National No. 328	5.00	2.90	46	38	22	27	10	70	242	2300	Low value due to d_2
National No. 329	8.00	3.25	54	44	23	11	47	84	361	4000	Yield in barrel
A. J. Meyer No. 3	2.35	1.30	28	21	11	11	19	41	037	1300	Yield in barrel Above average
A. J. Meyer No. 4	3.00	1.75	32	30	14	13	28	4	0062	1500	Yield in barrel
A. J. Meyer No. 6	4.50	2.50	42	32	19	23	31	60	161	2200	Yield in barrel
A. J. Meyer	8.00				20				172	2800	Failure in shank
A. J. Meyer	4.80	2.70	62	51	30	31	57	80	506	7000	Yield in barrel

Estimated load based upon average strength at yield point of barrel 41,000 lb. per sq. in. Average tensile strength barrel 60,000 lb. per sq. in. Average tensile strength of shank 130,000 lb. per sq. in.

Fig. 2.—Meyer, National, Bergius and Binet Turnbuckles.

Large Castings

	Tension		Compression		Shearing	
	Ultimate	yield point	Ultimate	yield point	Ultimate	yield point
	40,000	20,000	70,000	40,000	40,000	20,000
Modulus of elasticity (direct)						28,000,000
Modulus of elasticity (shearing)						13,000,000

Modulus of rupture in same ratios as above.
Steel Castings with Vanadium show about 20 per cent increase over the above values.

Strength of Special Steel Alloys—Lbs. per Square Inch

	Tensile strength		Yield point
Manganese	Up to 140,000	up to	90,000
Nickel	140,000		90,000
Chrome Vanadium	200,000		175,000
Chrome Nickel	140,000		100,000
Tungsten	170,000		150,000
Chrome Tungsten	185,000		160,000

Strength of Copper, Aluminum and Various Alloys—Lbs. per Square Inch

Cast Copper

Tension	22,000
Compression	45,000
Shearing	18,000
Modulus of elasticity (direct)	12,000,000
Modulus of elasticity (shearing)	8,000,000
Modulus of rupture (rectangular section)	35,000

Cold Rolled or Hammered Plates

Tension	32,000
Compression	60,000
Shearing	28,000

Cold Drawn Wire

Tension	50,000 to 60,000
Shearing	40,000

Modulus of elasticity of cold worked copper 17,000,000. Copper has no well defined yield point.

Cast Aluminum

Tension	14,000
Compression	25,000
Shearing	10,000

Cold Worked Aluminum Plate and Wire

Tension	24,000 (Plate)
Tension	40,000 (Wire)
Modulus of elasticity (direct)	6,000,000

Aluminum has no well defined yield point.

Duralumin

Tension 54,000 Compression 68,000 Modulus Elasticity 10,000,000

High brass	Tension 55,000	
Low brass	28,000	
Composition	30,000	
Bronze	30,000	to 75,000 varying with composition
Phosphor bronze	40,000	to 110,000 varying with form
Tobin bronze	80,000	yield point 50,000 hot rolled
Tobin bronze	100,000	yield point 70,000 cold rolled
Delta metal	45,000	Cast. Tension 70,000 cold rolled
Manganese bronze	70,000	lbs./sq. in.
	Compression 120,000 lbs. sq. in.	
Monel metal (hot rolled)	Tension (ultimate) 88,142 lbs. sq. in.	
	(yield) 38,000 lbs. sq. in.	
	Elongation in 2 inch 38 per cent	

The steel at present in common use among manufacturers is the mild sheet steel generally designated as cold rolled steel (C.R.S.). Whether its easy working qualities or its cheapness and easy supply has brought about this poor choice, is hard to judge. It is a relief to find that the constructors and the Government are endeavoring to do away with this most unreliable and inefficient of materials. Instances have only too often been brought to our attention when upon the completion of some small stamped fitting, the apparently solid metal is found to be of two distinct layers of thinner metal held together only at a few points. It is not well, however, to jump too quickly to the other extreme and attempt to use the very high strength alloys—requiring expert working and heat treatment. Companies to-day are, with a few exceptions, not in a position to undertake this added responsibility and the forcing of such delicate work upon inexperienced hands would be as dangerous as the present methods.

The following table outlines the general influence of chemical composition of the physical properties of steel:

	Tensile strength	Elastic limit	Ductility	Hardness	Hardening power	Brittleness	Resistance to shock	Resistance to vibratory stresses	Forgeability absence of red-shortness	Weldability
Carbon	+	+	—	+	(2)	+	(12)	+	—	—
Phosphorus	(13)	—	(3)	0		(4)	—	—	0	
Manganese	+	—		+					(5)	
Sulphur				0					—	—
Silicon			(6)	0					(7)	
Aluminum			(8)	0						—
Vanadium	+	—	(9)				+	+		
Chromium	—	—		+			+	+		
Molybdenum	—			+						
Tungsten	+	+		+						
Nickel	+	+	(9)	+			+	+		
Copper				0						(10)
Oxygen						+			(11)	
Nitrogen						+				

(1) + up to 1 per cent then —. (2) + up to 0.85 per cent. (3) 0 up to 0.1 per cent then —. (4) + over 0.1 per cent. (5) + up to 0.5 per cent. (6) — above 1.5 per cent. (7) — over 6 per cent. (8) — over 0.85 per cent. (9) — slightly. (10) — over 1 per cent. (11) — from 2 to 7 per cent. (12) + up to 0.3 per cent then —. (13) + up to 0.1 per cent then —.

The above table, while very comprehensive, should not be considered as final.

The matter of weldability of the chrome vanadium and nickel steel is indefinite, very reliable information showing that 3¼ per cent nickel steels give better welds than the chromium steel.

The S.A.E. Specification No. 3130 for a low carbon chrome-nickel steel, or Specification No. 2330 for 3½ nickel steel would seem to meet the requirements of the manufacturers as well as the Army Specifications of the S.A.E. No. 6130 chrome-vanadium, eliminating at the same time, the great danger of segregation due to faulty heat treatment.

Heat treatment and its influence cannot be gone into, it requires very careful study and infinite care in application.

Strength and Weight of Mild Steel Rivets and Pins

Diameter inches d	Strength in Pounds Single Shear	Double Shear	Crushing + t
1/8	1,000	1,600	1,200
3/16	1,600	3,000	1,800
1/4	2,750	4,500	2,400
5/16	3,900	7,000	2,800
3/8	5,000	9,800	3,600
1/2	9,000	17,800	4,800
3/4	20,000	40,000	7,200
1	31,500	71,000	9,600

The above values are based upon a shearing strength in pounds per square inch $f_s = 45{,}000$ and a crushing strength, $f = 96{,}000$.

$$P_s = f_s \frac{\pi d^2}{4} \text{ for single shear}$$

$P_c = f_c d t$, for crushing, where t, the thickness of the plate or other piece held by the rivet or pin.

The values for crushing have been worked out for a plate 1 inch thick, therefore the crushing strength for various thicknesses of plate may be computed by multiplying the above values by "t" in inches.

If the crushing strength of the rivet is greater than its shearing strength the design should be based upon the smaller result.

In case the bolt is subjected to a load other than tension, the strength should be based upon the corresponding form of loading. When bolts and pins are used in turnbuckle fittings and wire connections they are usually subjected to a form of bending and should be calculated as a beam round cross section loaded at the center.

$f = \frac{M_y}{I}$ where f = modulus of rupture, M = bending moment due to load generally considered concentrated at the center, y = distance from neutral axis to most strained fiber, in this case ½ D, I = moment of inertia of cross section.

In figuring bolts that pierce wooded members the failure of the wood should be considered first, since in this type of connection rupture is most often caused by the fastening pulling out or loosening due to the wood crushing in front of the bolts. The crushing load may be computed from the formula $P = f_c \times L \times D$. Where P = crushing load, f_c = crushing

strength of wood, L = length of bolt in wood, D = normal bolt diameter

United States Standard Bolts and Nuts

Nominal dia. D	Root dia. of screw thread (in.)	Gross area (sq. in.)	Eff. area root of thread (sq. in.)	Threads per in.	Short dia. of hex and sq. nuts (in.)	App. dia. across corners hex nuts	App. dia. across corners sq. nuts
1/4	0.185	0.049	0.027	20	1/2	0.578	0.707
5/16	0.240	0.077	0.045	18	19/32	0.686	0.840
3/8	0.294	0.110	0.068	16	11/16	0.794	0.972
7/16	0.345	0.150	0.093	14	25/32	0.902	1.105
1/2	0.400	0.196	0.126	13	7/8	1.010	1.237
9/16	0.454	0.249	0.162	12	31/32	1.118	1.370
5/8	0.507	0.307	0.202	11	1-1/16	1.227	1.503
3/4	0.620	0.442	0.302	10	1-1/4	1.443	1.768
7/8	0.731	0.601	0.420	9	1-7/16	1.660	2.033
1	0.837	0.785	0.550	8	1-5/8	1.876	2.298
1-1/8	0.940	0.994	0.694	7	1-13/16	2.093	2.563
1-1/4	1.065	1.227	0.891	7	2	2.310	2.828
1-3/8	1.160	1.485	1.057	6	2-3/16	2.527	3.093
1-1/2	1.284	1.767	1.295	6	2-3/8	2.743	3.358
1-5/8	1.389	2.074	1.515	5-1/2	2-9/16	2.960	3.623
1-3/4	1.491	2.405	1.746	5	2-3/4	3.176	3.889
1-7/8	1.616	2.761	2.051	5	2-15/16	3.393	4.153

NOTE—Depth of nut = nominal diameter. Depth of head = one-half short diam. of hex and sq. nuts.

The strength of United States Standard bolts in wood may be based upon the formula $P = A \times f_t$. Where P = the strength of the bolt, f_t = tensile fiber stress per square inch = 65,000, A = effective area at root of thread. Solving for D the nominal diameter $D = 1.24\sqrt{\frac{P}{f_t}} + .088$

Airplane Fabrics

The general requirements and tests for airplane fabrics are well summarized by the following table.

(1) Fabric should present reasonably great resistance to flame.
(2) It should be proof against the action of salt water, moisture, extreme dryness and sudden changes of temperature.
(3) It should not stretch in any direction.
(4) It should have a tensile strength of at least 75 lb. per inch width in any direction.
(5) The tendency to tear and split because of tacks, bullets, etc. should be almost nil.
(6) The weight should be taken in an atmosphere of 65 per cent relative humidity at 70° Fahr.
(7) The weight, yarn number and tensile strength of the fabric should be obtained in what is as a factory condition, i. e. after it has been subjected to a temperature of 220° Fahr. for two hours.
(8) Identity and average length of fibers should be ascertained.
(9) Determinations should be made of the percentage moisture regain under the available range of temperatures and humidity.
(10) A shrinkage determination should be made.

Some Representative Specifications, Strength and Weight Figures

In Table 4 are given some representative specifications which represent the average values of current practice.

TABLE 3

Specifications	Weight per square yard ounces	Threads per inch warp	Threads per inch weft	Strength per inch width (warp) lb.	Strength per inch width (weft) lb.
Curtiss No. 66 Oct. 26, 1916	4	96	100	91	102
R. A. F. No. 17-C; U. S. Army No. 1002	3.75-4.4	94	100	75	85 (minimum)
McKeesey tests	4	95	99	—	109
Clarence Whitman (cotton)	4	27 1 threads per sq. in.		67	60

Messrs. Lamb, Finlay and Co. have kindly communicated the average values of tests extending over a number of shipments, in accordance with British Government specifications.

"Three pieces are cut from the length and three pieces from the width of the goods. These samples must be long enough to leave 8 in. clear between the grips and sufficiently wide to leave the test pieces 2 in. wide after trimming. The test pieces are soaked in water for two hours. They are then taken out and the excess water is removed and the goods put in an Avery machine, the load being applied at the rate of 50 lb. per inch width per minute."

This method of testing, while apparently arbitrary, is convenient and avoids errors due to humidity changes, and is preferable to a test on dry material.

In the National Advisory Report the following figures are given for fabrics of different weights.

	Weight in oz. per sq. yd.	Strength Warp	Strength Filler
I	4.00	63.2	54.4
II	3.78	69.9	59.2
III	3.70	80.7	78.8
IV	3.04	89.0	74.0
V	4.16	92.7	90.7
VI	4.36	92.3	100.1
VII	4.60	95.0	90.8
VIII	4.36	90.4	106.5

TABLE 6
Approximate breaking strength

Quality	Width inches	Warp lb. per inch	Weft lb. per inch	Weight oz. per sq. yd.
A29	36	72	78	4.00 oz.
A31	36	108.1	94.6	4.00 "
A33	36	117	103.6	4.35 "
*A37	36	112	115.8	4.12 "
*A40	36	120.1	125.1	4.75 "

*[illegible]

Wing Dope and Varnish

The following notes on dope and varnish may be of interest to the manufacturer.

Dope alone on Irish linen surfaces has proven very satisfactory. Four to five coats, allowing about one-half hour for drying between each coat are ample protection for the most severe conditions. Very rigorous tests on samples exposed to the weather during the month of February resulted in no ill effects, the cloth remaining tight, glossy and without spots, cracks or tears. The weight of the covering is increased about 66 oz. per square yard per coat, with an application of approximately one gallon to ten square yards.

Varnish finish is recommended in many cases as more permanent and, being less effected by salt water, has some advantages on water machines. When repairing is to be done it is first necessary to remove the varnish before the patch is applied with dope, as it is a glaze, causing some inconvenience.

Doped surfaces have about 8 per cent to 10 per cent more strength and more resistance to tearing. It is necessary to redope all surfaces every three to five months.

Cotton and silk fabrics have a tendency to rot when covered with dope or varnish and such surfaces are not recommended.

References, Part 2, Section 5

Airplane Fabrics

First Annual Report of the National Advisory Committee on Aeronautics. Balloon and Aeroplane Fabrics, by Willis A. Gibbons and Omar H. Smith. Circular No. 41. Bureau of Standards.

Timber

Judge: Aviation Engines. [illegible] Adhesive, by Carl A. [illegible] Mills. Mechanical Properties of [illegible] Wood, by Koehler & Marks. [illegible] Applied Mechanics. The More Structural Properties of Wood, by Cecil J. Record (contributing numerous references). Reports of Tests on the Strength of Structural Material. [illegible] Publications of the U. S. Forest Service on "The Mechanical Properties of Wood and Timber Testing."

Metals

Materials of Construction. Prof. [illegible] Upton of Cornell University.

Wires and Cables

First Annual Report of the National Advisory Committee on Aeronautics. [illegible] (This also contains much valuable information on fastenings.)

Turnbuckles

Article in AVIATION AND AERONAUTICAL ENGINEERING, December 1 1916.

Aeronautical Patents

Copies of the above patents may be obtained for fifteen cents each by addressing the Commissioner of Patents, Washington, D. C.

1,221,234 Filed Jan. 14, 1908. To Charles N. [illegible]. Los Angeles, Cal. Aerial locomotion.

1,221,426 Filed April 4, 1916. To Joseph J. Duffy, Brooklyn, N. Y., assignor of one-half to Edward P. Ingersoll, Brooklyn, N. Y. Aerial torpedo.

1,221,430 Filed August 19, 1915. To Alfred Edward, Aberdeen, Wash. An airship.

ISSUED APRIL 10, 1917

1,220,140 Filed March 27, 1916. To William C. Robinson, Grinnell, Iowa. Airplane-fuselage structure.

1,220,409 Filed April 22, 1916. To Russell R. Waterman, Pasadena, Cal. Steering and propelling means for dirigible airships.

1,221,641 Filed September 2, 1916. To William James De La Mars, Des Moines, Iowa. An airship.

Emergency Landings in Cross-Country Flying

By Capt. Joseph E. Carberry

The specter of forced landing in cross-country flying, ever present to the disillusioned pilot of experience, often seems to be entirely disregarded by the younger generation of aviators. No doubt its presence robs flying of a great deal of pleasure, but the law of compensation will bring inevitably its own reward to the pilot who invariably follows certain well established rules that prudence and long experience have dictated.

It is assumed that every aviator in planning a cross-country flight will first acquaint himself with the character of the terrain he proposes to traverse. It is assumed that he will select his route after due deliberation and that he will plot his height at various points along that route with regard to the possible emergency of a forced landing. It is also assumed that he is thoroughly familiar with the flying characteristics of his airplane.

The first article of this cross-country flying creed, to which every flyer should subscribe, is to always keep a landing place in mind. Some area must be constantly in view in which a landing will be attempted if trouble develops which compels it. In a flight from Saltero to San Antonio, Mexico, over mountainous country, by flying a zig-zag course much in the manner of a person crossing a stream by stepping from stone to stone, it was possible for the aviator to have landed with safety to himself and passenger at any time. A straight cross-country flight to his objective in case of engine failure probably would have been disastrous. By careful routing flights may be made with reasonable security over apparently impossible country.

Photo [illegible]

CAPTAIN JOSEPH E. CARBERRY, U. S. A.

Choice of Field

The most important consideration of course is the landing field itself. It should be of sufficient size and of such surface as to permit of easy entry and exit. Choose landing places over which you have passed if possible to do so. If they are not available glide forward, always endeavoring to circle and examine conditions before committing yourself to it. If possible select several alternative landing places. Make no hasty decisions, but once having made one adhere absolutely to it. Remember that fields to right and left of your line of flight can be reached as easily as those directly in that line. Observe the approaches to possible landing fields and carefully scan them for fences, trees, and other obstructions. Telegraph wires, the dread of every flier, can generally be spotted by the poles. These should always be looked for. Be wary of landing in the immediate vicinity of bodies of water, as the neighboring ground often slopes abruptly. Exceptions of course must often be made to this rule. It may be the part of wisdom to follow a route with possible water landing places. In a recent flight from Philadelphia to Mineola engine failure near Staten Island compelled a flyer to land in the sea immediately off shore. No alternatives existed except populated or wooded areas. This landing was accomplished with damage in the propeller and minor damage to the fore part of the body only. The airplane itself was salvaged and was readily placed in commission again.

In inspecting your prospective landing fields keep the sun at your back. Endeavor also to land with the sun behind you. Especially is this important if the sun be low on the horizon.

A close observation of smoke along the course will be invaluable. If there be a strong surface wind indicated by these and other signs select possible landing fields with long axes in the direction of the wind.

Keep in mind that the aspect of fields changes materially with the seasons of the year. In case of doubt choose a cultivated area in preference to one not cultivated.

Manner of Landing

The wind is the most important element in this operation. Always land into the wind whenever possible. In gliding down to enter a field against a strong head wind, do not turn down from the wind in view in spiraling at low altitudes, but make "S" glides instead. At least the final 300 feet should be so timed that you may enter the field selected by a right angled turn. Your judgment of distance by this method with practice can be made almost perfect. In this connection the French training school rules call for straight away glides the last 500 or 600 feet.

Always keep a sharp lookout for all indications of wind at your landing place. I emphasize particularly "at your landing place." In one instance while descending at Chihuahua City, Mexico, an aviator observed smoke from a train on a railroad siding about five miles from the landing place chosen. Due no doubt to immediate local conditions the wind at this landing place, very strong and very gusty, was in an almost opposite direction. As a result after landing he was unable to reduce his ground speed and ran into a heavy mesquite field damaging the lower wings severely and preventing further flights that day.

Particular attention should be paid in practice flights to slow landings. This is essential when landing is to be made in heavy plowed fields, in snow or water. Under these conditions, always head into the wind, even if other considerations are somewhat against that procedure and stall for at least the last three or four feet. Remember to keep the tail well down. If compelled to land in a side wind watch for possible obstructions, under the shelter of which you may complete your run on the ground. While flying at Buffalo, New York, from a narrow field bordered by high trees on one side, an aviator was able to take off and land successfully by keeping in the lee of these trees, which almost entirely broke the prevailing cross wind. Endeavor to make your glide at as moderate an angle as possible. A prolonged descent at a fairly steep angle will result in ultimately attaining the same speed as a dive over a short distance. The slowest possible landing should be your ideal in cross-country flying.

Finally the type of airplane that you are flying should always be considered. For example a tractor airplane with inclosed body may be maneuvered into a remarkably small area by violently skidding just before landing and then straightening out before the wheels touch the ground. Especially is a knowledge of this art valuable when it becomes necessary to enter after diving over obstructions. This requires a delicate touch at the wheel.

Above all, keep your airplane under control until the very last. Strict adherence to this rule will often result in landing without damage to the persons of the pilot or his passenger. Never despair of affecting a landing with safety to yourself, however formidable the aspect of the ground below you may be.

Manufacturers Wish Catalogs and Samples

The Aircraft Manufacturers' Association of 501 Fifth Avenue, New York has requested the widest possible publicity for the following notice which is of great importance in connection with the Association's efforts to introduce standardization:

"At the regular monthly meeting of the Aircraft Manufacturers' Association held on Wednesday, April 11, at 501 Fifth Avenue, New York City, the secretary was instructed to get into communication with all manufacturers of finished products and producers of raw materials entering into the construction of aircraft of all descriptions.

The Association desires particularly to receive small samples of fabrics suitable for wing covering, tubing, wood veneer, catalogs of fittings, instruments and general equipment."

U. of P. Alumni Offer Six Planes

Interest in recruiting for the University of Pennsylvania's student battalion has been increased by the offer of six airplanes by wealthy alumni and the work of forming the air corps will begin shortly according to newspaper reports. About sixty men will be needed to operate the machines and keep them in condition. The machines will be delivered as soon as needed.

Advisory Committee Report on Patent Situation

On March 2, 1917, Congress appropriated one million dollars

"to enable the Secretary of War and the Secretary of the Navy to secure, by purchase, condemnation, donation or otherwise, such basic patents as they may consider necessary to the manufacture and development of aircraft in the United States for governmental and civil purposes."

This action was taken on account of the general belief that the needed expansion of the aircraft industry calling for the investment of large sums of money was being very seriously impeded by threatened law suits and the demand for the payment of what was looked upon as excessive royalties under certain important aeronautical patents. One such demand upon the manufacturers called for a royalty of five per cent on the price of the complete plane with motor and a minimum annual payment of $10,000 per manufacturer.

All makers in bidding for government business were obliged to add to their bids an extra amount representing the royalty they would have to pay under this one patent alone and the Army and Navy were confronted with many bids in which the contingent royalty amounted to over $1000 per airplane.

The National Advisory Committee for Aeronautics in whose hands the problem was placed for recommendation realized that it would be undesirable to use the fund provided for the purchase of patents until every means had been exhausted to secure a settlement on a reasonable basis between the different parties in interest. It realized that even in our present need it would be unwise to condemn a patent except as a last resort. The National Advisory Committee for Aeronautics is particularly anxious to encourage invention along aeronautical lines instead of discouraging it.

In reviewing the records of the Army and Navy Departments as to planes purchased during the eight years prior to current heavy appropriations for national defense it was brought out that four men in four different factories supplied all of these planes and apparently contributed most in the development and reduction to practice of the aviation art. These named in the order of their appearance in the records are Wright, Curtiss, Burgess and Martin. By a strange coincidence Curtiss and Burgess joined hands and later the Wright and Martin interests came together.

While there are other aircraft patents it was found that these two combinations owned and controlled what might be considered the two dominating groups of patents.

The National Advisory Committee has therefore been influenced to a slight extent in its consideration of the patent question by the moral obligation that should be added to the patent rights of these two groups. Recognition of two groups of patents by the later industry and by the government becomes automatically recognition of practically all of the actual reduction of the art to practice by Wright, Curtiss, Burgess and Martin.

Numerous meetings were held in New York, Buffalo and Washington in an endeavor to arrive at a basis of settlement that would comprehend all of the patents owned or controlled by each group, that would be a fair recognition of their patent rights and that would at the same time cement together and strengthen the industry.

Basis of the Committee's Plan

The plan finally agreed upon by the Committee and submitted to the two companies for their consideration and early report is framed upon the following basis:

1. That it is desirable to avoid the delays and expense necessary to adjudicate all of the patents in question.

2. That it is not within the province of this Committee to attempt to determine the value of one patent against another or the validity of any patent.

3. That it is desirable at once to arrive at some fair basis for the recognition of the patents of both parties that will clear up this matter and permit the more rapid expansion of the industry.

4. That the relative contributions to the establishment of the aircraft industry as between Wright and Martin on the one hand and Curtiss and Burgess on the other hand may be said to offset each other and that the recognition of each should be in the same total amount.

5. That by reason of Curtiss patents running approximately three times as long as Wright's the royalty to the Curtiss-Burgess group might be made about one-third of the amount per plane to be allowed to the Wright-Martin group.

6. That instead of endeavoring to establish a difference as between airplane, seaplane or flying boat the royalty should be spread uniformly upon all three types.

7. That the royalty should be a flat rate on each plane with or without engine instead of a percentage of cost or selling price.

8. That royalty should commence upon all planes manufactured and sold after March 2, 1917, and that those manufactured and sold prior to that date be exempted from royalty.

In submitting this plan the National Advisory Committee for Aeronautics has not attempted to draw up a finished legal approval agreement but instead to present its plan in the simplest possible form.

Proposed Plan

1. That all airplane manufacturers as members of the Aircraft Manufacturers Association join in a cross-licensing agreement as of March 2, 1917.

2. That this agreement cover all patents now owned or controlled by or which may later be owned or controlled by the Aircraft Manufacturers Association or any of its members, the terms of the cross-licensing agreement to be in general based upon the similar agreement existing in the National Automobile Chamber of Commerce known as the "Cross Licensing Agreement."

3. That each member pay into the treasury of the Aircraft Manufacturers Association the sum of $200.00 for each airplane manufactured and sold (with or without engine) by that member. These payments to be made quarterly and to continue subject to the conditions hereinafter provided.

4. That the funds thus collected be disposed as follows:

At each quarterly period for each airplane manufactured and sold during the preceding quarter there shall be paid:

$1[illegible] to the Wright-Martin Aircraft Corporation
$[illegible] to the Curtiss Aeroplane & Motor Corporation
$25 to the treasury of the Aircraft Manufacturers Association to cover its operating expenses and to create a fund for further development.

5. Payment to the Wright-Martin Aircraft Corporation shall cease May 22, 1923, and payment to the Curtiss Aeroplane and Motor Corporation shall cease at such time as the total amount paid to them shall equal the amount paid to the Wright-Martin Aircraft Corporation, but in any event shall cease October 30, 1933.

6. After May 22, 1923, the amount paid per airplane by each manufacturer shall be reduced by the amount of the Wright-Martin royalty which will have ceased on that date and shall thereafter be $65.00 per airplane manufactured and sold during such remaining period as payments of royalty are made to the Curtiss Aeroplane and Motor Corporation as above provided for.

7. An airplane as herein mentioned shall be understood to mean any form of heavier than air craft using wing surfaces for sustentation, stabilizing surfaces, rudders for steering and power plant for propulsion through the air, whether operated from land or water.

C. D. Walcott, Chairman. S. W. Stratton,
Member. [illegible], U. S. A.
Member. S. [illegible], U. S. N.
Member.
Subcommittee on Patents.

Proposed Aerological Stations

An effort is being made by the National Advisory Committee for Aeronautics to promote the study of the atmosphere over this continent and the adjacent waters, and have a set of accurate charts made for the benefit of our aviators.

Especially is this problem vital as it concerns the national preparedness program. This fact was brought out by a telegram read at the Aero Club of America banquet recently in New York from Dr. Charles D. Walcott, secretary of the Smithsonian Institution and chairman of the executive committee of the National Advisory Committee for Aeronautics, who advised that the assembled members urge most strongly the establishment and maintenance of aerological surveys over North America and the adjoining waters for the protection of the lives of United States aviators, the safety of aircraft and the furtherance of their operation.

"At present," stated Dr. Walcott, "practically nothing is known of the movements of the fluid in which shortly thousands of aircraft representing millions of dollars in investment will be floating, and what is far more important there will be operated at [illegible] the lives of our finest specially trained young men."

Advisory Committee's Activity

During the past twelve months the National Advisory Committee for Aeronautics met with manufacturers of airplanes and airplane engines in an effort to expedite the delivery of machines to the Government and has been of great assistance in the solution of many other problems.

Now it proposes that earnest thought be put on the vital necessity of recording and charting the irregularities of the atmosphere so that our aviators in peace or in war may have the benefit of exact information both for their own safety and as an expedient to efficient operation of aerial messenger, reconnaissance and fighting service.

An estimate of appropriation of $100,000 for the establishment of special aerological stations in connection with the United States Weather Bureau will be brought to the attention of Congress.

Aero Club Banquet

The eleventh annual banquet of the Aero Club of America was successfully held in the Waldorf-Astoria hotel, New York, on the evening of March 30. Alan R. Hawley, president of the Aero Club of America, presided and Henry A. Wise Wood acted as toastmaster. Among the speakers were Hon. James W. Gerard, former Ambassador to Germany; Major General Leonard Wood, U. S. A.; Rear Admiral Robert E. Peary, chairman of the National Aerial Coast Patrol Commission; Stephane Lauzanne, editor of the Paris *Le Matin*, and Godfrey L. Cabot, president Aero Club of New England.

Miss Geraldine Farrar sang the "Star Spangled Banner."

A number of congratulatory messages were read at the banquet.

Howard E. Coffin's Message

Howard E. Coffin, a governor of the club and member of the Council of National Defense, wired as follows:

"I desire to congratulate the club upon its share in the [illegible] of [illegible] during the past year and impress upon our members the [illegible] need for the most intimate and [illegible] cooperation both with the military departments and with the newly formed Manufacturers Association. The influence of the Advisory Commission of the Council of National Defense will be exerted in favor of the adoption of a three-year construction program with a definite assignment to each manufacturer of his part in the work. We must have standardization so far as possible in materials and in the details of design, and the number of models assigned to each factory must be reduced to a minimum. It is only through a proper classification and concentration of our industrial resources in this industry that we may hope to make definite progress in the art so vitally necessary to the defence of this nation."

Sperry Awarded Collier Trophy

The Robert J. Collier Trophy, which is awarded annually for the greatest achievement in aviation in America, the value of which has been demonstrated by use during the preceding year, was awarded to Elmer A. Sperry and Lawrence B. Sperry for the development and demonstration of the Sperry drift indicator.

The following awards of merit were also awarded:

To Miss Ruth Law, American distance record, [illegible] November [illegible] 1916, [illegible] miles.

Philip A. Carroll, for his patriotic work in training military aviators at Governors Island, 1916.

Floyd Smith, American hydro altitude records, January 12, 1916, one passenger 12,[illegible] ft.; January 11, 1916, two passengers [illegible]; February [illegible], 1916, three passengers, [illegible]

Corporal A. [illegible] Smith, U. S. A., American hydro duration record, [illegible], 1916, 8 hrs. 42 min.

Captain [illegible] Culver, U. S. A., for wireless experimentation [illegible]

James V. Martin, for the invention of the aerodynamic stabilizer.

Aerial Coast Patrol Unit No. 1, for its pioneer work in developing aerial coast defense.

1st Aero Squadron, U. S. Aviation Section, [illegible] at the Mexican Border, 1916: Major B. D. Foulois, Capt. T. F. Dodd, [illegible] Capt. [illegible], Capt. [illegible] Bradley, Capt. [illegible] Chapman, Capt. [illegible] Capt. [illegible] Willis, Capt. T. S. Bowen, Capt. [illegible] Carroll, Capt. [illegible] Christie, Capt. T. S. Dodd, U. S. A.

Victor Carlstrom, three additional bars to Medal of Merit he already holds for: American Altitude Records, April [illegible], 1916, one passenger [illegible]; April [illegible], 1916, two passengers, [illegible]

American Distance Cross Country Record, May [illegible], 1916, one passenger, [illegible] miles.

Winning of the Curtiss Marine Flying Trophy for 1916.

T. [illegible] three additional bars to Medal of Merit he already has for: Naval [illegible] Closed Circuit Record, May [illegible], 1916, five passengers, [illegible] miles; American Hydro Altitude Records, May 4, 1916, five passengers, [illegible] ft.; April 30, 1916, six passengers, [illegible] ft.; American Hydro Duration Record, May 4, 1916, five passengers, 2 hrs. 23 min.

One of the features of the banquet was the announcement that Rodman Wanamaker offered a large twin engine flying boat to the United States Government.

American Searchlight Stops Zeppelin Raids

Reports recently received from England indicate that it is an American invention, the new Sperry searchlight, which is one of the two factors that have rendered recent Zeppelin raids on London abortive. It is said that the new carbons used in these lamps to increase their intensity have been among the most important factors in frustrating the Zeppelin raids.

This lamp has been used recently for experimental work on the aviation field at

[illegible] Sperry [illegible] Searchlight

Mineola. It illuminates a target ten times as brilliantly as an ordinary projector and its arc is as bright as sunlight.

The brilliancy of this lamp is due among other things to the special carbons. The arc burns at a temperature of 10,000 degrees Fahr. The candlepower of the 36-in. Sperry searchlight exceeds 1,250,000,000.

An important feature of this searchlight is the remote control, which is very desirable for anti-aircraft work. By means of this apparatus the lamp can be operated even upward at an angle of 90 degrees from a distance as great as one mile. This lamp can be used for other purposes such as coast defense work, for which its long range makes it specially suited. The 60-in. Sperry searchlight has been seen 150 miles away. The lamp can also be used for signaling and is installed on naval vessels.

The installation of these new searchlights together with the use of incendiary bullets for machine guns is said to have resulted in the stopping of Zeppelin raids on London. Searchlights stationed at coast towns pick up the Zeppelins and permit the heavier-than-air machines to destroy them.

Packard Engine Progressing

The 200-horsepower aircraft engine which the Packard Company has been developing in the past two years is said to be about ready to take flight. The process of installing the engine in a specially constructed plane is now going on rapidly.

Final work on the engine has been hastened by developments in the international situation that may create an urgent need for aircraft in America.

The flying tests of the new engine will be made at the Joy aviation field near Mount Clemens, Mich., where there are unusual facilities for trials over both land and water.

W. B. Stout, chief engineer of the Packard aircraft division, says that the machine will be capable of 90 miles an hour. A fast climb is also expected.

Fort Omaha Notes

Frequent flights in free balloons are being made from the Fort Omaha, Neb., school.

On one flight a few days ago Pilot Leo Stevens with Capt. John Prentice and Lieut. J. F. Davidson ascended at Fort Omaha at 1.30 p. m. and landed at Dagonal, Iowa, ninety miles away, at 6.08 p. m.

Sixty Miles an Hour

On March 24 Leo Stevens with Captains Prentice, Muller and McElgin and Lieutenant Davidson made what is believed to be a new record for speed in a free balloon, traveling from Fort Omaha to a point seven miles from Marksburg, Iowa, a total distance of over a hundred miles, in one hour and forty minutes.

Notes of the Memphis Training Station

Captain Joseph C. Morrow, Officer in Charge, has returned from a trip to Fort Barrancas, Fla., where he completed his examination for promotion.

A. B. Lambert, vice-president of the Aero Club of America, visited this school March 14 and while there he was taken for a passenger flight in one of the school's new machines.

Captain A. R. Christie, Officer in Charge of Training, has established a construction and repair department under the direct supervision of Chief Mechanician Hauser. Five sergeants of the Signal Enlisted Reserve Corps have been directed to report to Mr. Hauser for practical instruction in overhauling machines.

Reception of First Tennessee

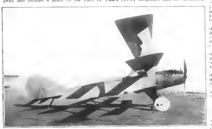
A feature of the reception arranged in honor of the First Tennessee troops when they returned from the Mexican border was the flight of a squadron of nine airplanes southward and over and parallel with the parade of troops. Forty-five parachutes were dropped from the machines in flight. To each parachute was attached a small American flag and a pennant on which was typed "U. S. Aviation Station, Memphis, welcomes the First Tennessee." Captain Joseph C. Morrow, Officer in Charge, as observer, and Captain A. R. Christie, Officer in Charge of Training, as pilot, occupied the leading machine. The eight other machines were piloted by flying instructors and student instructors, each accompanied by a sergeant of the Signal Enlisted Reserve Corps (applicants for commissions in the Signal Officers Reserve Corps) who acted as observers. Each observer made a written record of his observations which he submitted to the Officer in Charge of Training after the flight. The following is one of the reports submitted:

"First machine rose from the aviation field at 9.08 a. m. March 18, 1917.

"Squadron climbs an altitude of [illegible] feet at [illegible] a. m. After circling the field squadron turns southward 9.12 a. m. City seen to the north and large river to the westward. River lying in a north and south direction. Two large bridges cross the river from the city side. Three steamboats in midstream, one with log raft in tow. Four steamboats lying at wharves. Arrived over business section of city at [illegible] a. m. Good wagon roads enter the city from north, northeast, east, southeast and south. Railway stations, shops and yards west side [illegible] river. Public buildings, probably post office, custom house and courthouse north and east of business district. Railroads enter city from north, east and south. A possible landing place for airplanes on west side of river and about 3 miles south of large bridge. Another possible place for landing in public park east side of city. Territory surrounding the city covered with water in many places and thinly wooded, water supposed to be due to recent heavy rains. Automobiles, wagons, pedestrians and wagons seen in streets of city. Streets run north and south and east and west. Squadron turned to land shortly after taking the air, has reached the field in safety by gliding. Rear unit of squadron returned to field at 10.45 a. m."

Duesenberg Refinanced

The Duesenberg Motors Corp has succeeded the Duesenberg Motor Co., St Paul, and the Loew-Victor Engine Co Chicago, its capital being $1,500,000 of which $1,050,000 is paid in. The company has located a plant in the East at



The above photograph shows the latest pattern of the Curtiss Model L pursuit triplane. Recent changes which are noteworthy are the raising of all three sets of planes, shortening the span and introducing a dihedral angle into the bottom plane and greatly increasing the gap between the center and top planes

Edgewater, N J. The engineering and experimental forces have already moved from Chicago and the company will, in a short time be building on a commercial basis a line of Duesenberg engines for both automobiles and aeronautical purposes devoting the output of the Chicago plant to marine models. The Loew Victor Engine Co has been building one of the largest high-speed marine gas engines on the market for the past year. These motors were designed by F. S. Duesenberg. The Chicago plant will in the near future be consolidated with the Edgewater plant. The sales and executive offices of the company will be at 120 Broadway, New York.

The personnel of the organization is as follows: Directors J R Harbeck, F S Wheeler, Charles Stollberg, K S Breckenridge, L. A. Welles and F R Page. The first five are all of one of America's largest industrial corporations. Mr Page is vice-president and general manager of the E W Bliss Corp.

J R Harbeck who was president of the Loew Victor Engine Co since its formation, is president and managing director of the Duesenberg corporation. E L Decker is assistant to the president; H A. Wing is secretary and treasurer; C B Page is general manager in charge of production and N G Rose is general sales manager. F S Duesenberg is chief engineer. A S Duesenberg is assistant engineer. M M Whitaker is assistant engineer and naval architect. G. A. Bell ... is purchasing agent and F E Lamps is superintendent.

Frank H Trego Has Factory

Frank B Trego has purchased the factory buildings of the A C Gilbert Co at Fox and Ferry Streets, New Haven, Conn. The Trego Motors Corp was formed a few days ago with a capital of $1,500,000, to build engines, airplanes and flying apparatus.

Yale Unit Officially Recognized

The Yale flying unit known last summer as Aerial Coast Patrol Unit No 1, a voluntary unofficial designation, has enrolled in the Second Naval District Coast Defense Reserves. Mr Davison has provided twelve airplanes and all necessary equipment for the Yale flying unit.

The aviators are practising in Florida now and will come to Newport when ordered to active duty.

Flint Aircraft Co Organized

The Flint Aircraft Co Inc of Flint Mich has been organized by several well known automobile men and has taken over the Williams Aeroplane Co of Fenton. W W Clark Jr., of the Buick Motor Co has been elected president and Frank Freeman, secretary treasurer. The other directors are Dr C H Bahlman, W F Stewart, president of the Stewart Body Co and Harry Bassett all of Flint. Egbert B Cresswell, formerly with the Thomas Brothers Aeroplane Co is the general manager of the new company. The company's plans have not yet been announced.

Henri Julliot with Goodrich

Henri Julliot, French builder of dirigibles, is in this country supervising the erection of the dirigibles which the Government is having built by the B. F Goodrich Co.

He built the big dirigibles, "Le Jaune," "Lebaudy," "La Republique," "La Liberte" and "La Patrie." His first military dirigible was built in 1902 before Count von Zeppelin had made his first balloon.

"The United States will need many dirigibles in hostilities with Germany," M. Julliot declared. "They are essential for coast defense. The larger dirigibles can go out to sea for 500 miles and watch for enemy fleets."

Because they can stand still in midair and because they can carry 6000 to 8000 pounds of explosives in addition to their own weight they will play a big part in naval offensive operations.

"To become an operator of a military dirigible one must have youth, a few months' training and a working knowledge of physics and mechanics."

M. Julliot will spend two or three years in this country designing and supervising the construction of military dirigibles.

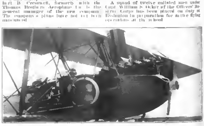
Guard at Essington Station

Rather than take any chance on having some German sympathizer or agent destroy the airplanes now at the Philadelphia School of Aviation at Essington, Robert E Glendinning, head of the school, is paying a squad of watchmen to guard the machines at night. This he will continue to do, he says, until the United States Government takes possession of the organization. This action is daily expected.

The work of the school is seriously handicapped owing to the lack of machines according to Mr Glendinning. There are now more than 300 applications for training hanging fire because there are not sufficient machines for that purpose. Ordinarily the school has only two planes, but both Mr Glendinning and George Thomas have placed their private machines at the disposal of the students.

The Government has notified the school officials that they are sending twelve more machines to Essington but as yet they have not arrived.

A squad of twelve enlisted men under Capt William S Ocker of the Officers' Reserve Corps has been placed on duty at Essington in preparation for active flying operations at the school.



Martin Model R Reconnaissance Tractor with New Double Opposed Two-Cylinder Indian Motorcycle Fitted Alongside the Body

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, of AVIATION AND AERONAUTICAL ENGINEERING published semi-monthly at New York, N. Y., for April 1, 1917.

State of New York }
County of New York } ss

Before me, a Notary Public in and for the State and county aforesaid personally appeared Lester D. Gardner, who, having been duly sworn according to law, deposes and says that he is the President and Editor of the Gardner, Moffat Co., Inc., Publisher of Aviation and Aeronautical Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are:

Publisher, The Gardner, Moffat Company, Inc., 120 West 32nd St., New York, N. Y.; Editor, Lester D. Gardner, 120 West 32nd St., New York, N. Y.; Managing Editor, Herbert S. Williams, 120 West 32nd St., New York, N. Y.; Business Manager, Lester D. Gardner, 120 West 32nd St., New York, N. Y.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

The Gardner, Moffat Company, Inc., 120 West 32nd St., New York, N. Y.; Lester D. Gardner, 120 West 32nd St., New York, N. Y.; William I. Sumner, 20 Exchange Place, New York, N. Y.; William D. Moffat, 222 Fourth Ave., New York, N. Y.; Joseph H. Colt, 120 West 32nd St., New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

LESTER D. GARDNER.

Sworn to and subscribed before me this twenty-ninth day of March, 1917.

[SEAL.] MANGHILD A. LINDBLOM

My commission expires March 30, 1918.

Aeronautical Trade Directory

Aviation and Aeronautical Engineering will furnish information and addresses of all companies listed below. Names of Advertisers in this issue are printed in heavy face type.

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Davis-Bournonville Co.
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